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Systematic analysis of industry engagement activities on student learning in the undergraduate technology program

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Systematic analysis of industry engagement activities on student learning in the undergraduate technology program

by

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TABLE OF CONTENTS

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ABSTRACT

Industry engagement is used alongside classroom learning to provide students with the best possible learning experience before graduation. There are a variety of engagement activities which may be utilized by the instructor to help students learn and apply classroom content. Time and resources are used by both the instructor and the industry personnel to arrange the student activity. Thus, it is imperative that the activities used by instructors are providing students with the best possible learning experience. Approximately 75% of students graduating with a technology degree from Iowa State University are transfer students who come into the program sometime after their freshman year. Therefore, this study will focus on survey responses from the junior and senior classes. This thesis examines and defines what students learn from different industry engagement activities. Then, the seven activities are compared using *t*-tests, a Bonferroni adjusted alpha level, and the effect size of the difference of the mean scores, to determine which activity or activities are most effective at enhancing junior and senior learning. Based on the research, it showed that all industry engagement activities with the exception of professional organization involvement had a similar impact on student learning for juniors and seniors.

CHAPTER 1. INTRODUCTION

Industry engagement activities are used as supplementary material to help students gain an understanding of how classroom learning is applied to real-world situations. Various industry engagement activities have been researched to see what students learn during the activity or how the activity impacted the student. The previous literature has confirmed that all the activities being reviewed in this research have a positive impact on student learning (Patil et al., 2012; Perkmann, 2007; Rodrigues, 2004; Schambach & Dirks, 2002; Smith et al., 2009). However, little research has been completed to compare activities to see if students have greater learning from one activity over another. This work defines six aspects of learning: (a) skills used or applied, (b) daily job duties, (c) workplace culture, (d) pursuing a career in the field, (e) applicable course work, and (f) learning about a potential employer, which students gain from the activities and compares the seven activities: (a) case studies, (b) internships, (c) industry tours, (d) industry videos, (e) industry focused final projects, (f) professional organization involvement, and (g) guest speakers, using the aspects of learning. This will provide a measure for instructors to determine which kinds of industry engagement activities they may include in their classes.

Though this study focuses on students and their learning, it is important to note that students are not the only participants who profit from industry engagement activities: education institutions and the industries who participate in the activities also profit from being engaged with the students. Educational institutions are able to gain research opportunities through contact with industry personnel, as well as sending well-rounded students out into the industry upon graduation (Perkmann, 2007; Perkmann et al., 2013). The industries involved with industry engagement activities are able to gain the research opportunities through the educational institution and are able to network with students to provide internships which could lead to full-time jobs upon graduation.

Research Objectives

The overall goal of this project was to assess the impact of industry engagement on student learning for technology students. Providing instructors with a measure of how effective the different activities will allow instructors to incorporate those activities which correlate to student learning. This thesis is made up of two research papers and the objective of each paper was to (1) identify learning outcomes from industry engagement activities and (2) to compare industry engagement activities to see if they have similar impact on juniors and seniors.

Thesis Organization

This thesis is organized into two main chapters. Chapter 2 of this thesis is titled “A Meta-Analysis of the Effect of Industry Engagement on Student Learning in Undergraduate Programs.” This research reviews scholarly work to determine what students learn during the industry engagement activities. The research also suggests incorporating the plan-do-check-act quality tool as a check to see how the activity being used currently is working to provide more information about the classroom learning. The results from this research are published in the *Journal of Technology, Management, and Applied Engineering* (*JTMAE*). Chapter 3 of this thesis is titled “Systematic Analysis of Juniors and Seniors Learning Through Industry Engagement Activities.” This research defines the six aspects of learning which are used to compare the seven industry engagement activities using *t*-tests, a Bonferroni-adjusted alpha level, and the effect size of the differences between juniors and seniors. Chapter 4 will provide an overall conclusion of the research. Throughout the thesis, the references are included at the end of each chapter.

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CHAPTER 2. A META-ANALYSIS OF THE EFFECT OF INDUSTRY ENGAGEMENT ON STUDENT LEARNING IN UNDERGRADUATE PROGRAMS

Modified from a paper published in the *Journal of Technology Management and Applied Engineering (JTMAE)*

Caleb Burns and Shweta Chopra

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Abstract. *Universities incorporate industry engagement alongside classroom teaching to prepare today's students to become tomorrow's entrepreneurs, workers, or researchers to make the world a better place. Successful industry engagement activities provide students with life-changing experiences that can: (a) enhance students' networking connections with professionals who can potentially provide employment references and future job positions, (b) give students an opportunity to gain practical experience by observing and applying the methods and theories learned in classroom to real-world scenarios, (c) allow students to gain experience in their prospective career path, and (d) improve students' professional communication skills. Existing research has suggested that student learning is enhanced through industry engagement. However, most research has focused on individual industry engagement activities such as internships, plant tours, case studies, etc. There has been little research on the holistic evaluation of the effectiveness of multiple industry engagement activities. For this study, a review of various engagement activities was conducted and ways in which these activities were useful not only for students but also for the industry and the* *educational institution were identified. Once best practices for most effective industry engagement activities are identified, they can be utilized for creating a more methodical learning environment. This study provides a framework using continuous improvement for a holistic evaluation approach to be implemented when engaging in multiple industry activities. From this study it was identified that each industry engagement provides valuable learning experience to students. Industry engagement not only enhances learning for students but it also provides a vision about their future career. Similarly, industry representatives gain an opportunity to interact with students to learn about the curriculum and the student's skill sets.*

Keywords. *Industry engagement, student learning, classroom*

Background

College–industry collaboration is a vital component of successfully preparing undergraduate engineering and technology students for their professional endeavors. This collaboration allows students to engage in up-to-date industry practices, learn more about their major, and develop skills to be more effective students (Herrmann, 2013). Applying course content to workplace challenges provides students with an opportunity to bridge the gap between their classroom education and real-world experiences. Providing students with the ability to become engaged with industry professionals is the first step in closing that gap. Faculty members must incorporate a variety of teaching techniques because students comprise a diverse group and do not all learn in the same way (Rodrigues, 2004). Teaching techniques can fall into two main categories: active learning and passive learning. These two categories, as well as how industry engagement activities can be considered either active or passive learning, are discussed in more detail in the following paragraphs.

Passive learning techniques comprise the more traditional learning styles. Rodrigues (2004) defined passive techniques as lectures by the instructor, reading textbooks, guest speakers, videos shown in class, and student presentations. Passive learning relies on individual students to learn by way of lectures or books rather than through interactions with other students or instructors (Hwang, Lui, & Tong, 2005).

Dewey (1997) designed active learning techniques that allow students to become more engaged in the learning process. Active learning techniques use students' prior knowledge to develop the skills needed to solve problems (Rodrigues, 2004). Rodrigues (2004) suggested various active learning techniques such as case studies, individual research projects, group projects, and classroom discussions. Active techniques can also involve students working together in small groups to solve a problem (Hwang et al., 2005). Braxton, Milem, and Sullivan (2000) defined active learning as activities that require students to accomplish a task, such as solving a problem, and then to reflect on that task. Active learning activities include discussions among peers and cooperative learning experiences (Braxton et al., 2000). When students observe, experience, and/or practice what they have learned, they are usually able to retain the information better (Nilson, 2010). Braxton et al. (2000) discovered that students who partake in active learning believe their college experience is rewarding on a personal level and thus are better able to retain information. Graham, Tripp, Seawright, and Joeckel (2007) stated that active participation in the learning process has a positive effect on academic achievement.

Student industry engagement techniques are a vital part of improving a student's learning experience (Rodrigues, 2004). Smith et al. (2009) stated that students who are engaged with industry during their coursework often succeed in their career after graduation. Professors and lecturers can include student engagement activities in their courses along with their lectures to provide students with the best possible learning experience. The present study focused on reviewing student learning outcomes resulting from various teaching techniques used in multiple industry engagements. Some of the industry engagement activities reviewed in this study were active activities and others were passive, as defined by the literature. This study focused on reviewing industry activities using a holistic approach. These activities represent those currently used in university curricula, and it is important that they be evaluated to gain understanding of their effect on student learning.

In the following sections of this paper, the literature review section first presents a discussion on different definitions of engagement, including the definition of engagement used for this study, and then presents a discussion of various teaching techniques and expected learning outcomes. Next, the discussion section introduces the various benefits for the three stakeholders (industry, educational institution, and students) involved with industry engagement. Finally, based on the literature, two topics for future work—to holistically review industry engagement activities and to provide an idea for implementing continuous improvement—are presented.

Literature Review

Defining Student and Industry Engagement

There are three stakeholders involved in student industry engagement activities: the industry, the educational institution, and the student. To elaborate, students take classes at the educational institution that prepare them for their future professional endeavors upon graduation. Educational institutions collaborate with industry to create opportunities for students to experience how classroom learning can be applied to industry. This industry–university collaboration may allow for future cooperative research opportunities, which could provide students an opportunity to participate in that research.

Literature on the scholarship of teaching and learning provides a number of definitions of engagement. One definition states that student engagement is student involvement with an in-class or out-of-class learning activity (Trowler, 2010). Another definition states that student engagement is more related to student feedback, student representation, and student approaches to learning in the classroom (Coates, 2005). Being engaged means students have to do more than just show up for an activity; rather, they must participate intellectually and physically in the activity and gain further understanding about the subject matter through such involvement (Graham et al., 2007). Harper and Quaye (2009) defined engagement as students being involved in a conversation, asking questions, and being part of the activity. Hu and Kuh (2001) defined engagement as students' efforts to be involved in activities undertaken for their learning. A student must choose whether or not he or she wishes to be engaged in learning activities. Faculty members may assign credit for activities, but it's still up to the student whether or not to be engaged. A student may participate in the activities, but that does not assure active engagement.

For the current study, industry engagement was defined as a student's active participation in various industry activities, such as an industry tour, a guest speaker, a case study, an internship, involvement with a professional organization, a virtual plant tour, and industry-focused final projects, that are conducted as a part of the curriculum. Krause (2005) defined active participation as when students are involved with student-centered activities or learning experiences that require students to reflect on their experience.

Industry Engagement Activities

Internship/cooperative experiences

Smith et al. (2009) defined internships and cooperative experiences as those in which students are in the workplace gaining experience that is accompanied by classroom learning. These kinds of learning experiences have been studied to determine what aspects of student learning occur during such assignments. According to Cates and Jones (1999), transfer of knowledge or learning during cooperative activities occurs when students take previous knowledge and implement new ideas. Schamback and Dirks (2002) suggested that students are able to reinforce their previous educational coursework during a cooperative or internship experience. Upon completion of an internship, students should (a) have a better understanding of classroom learning and ways in which the knowledge gained in the classroom relates to the work environment, (b) have more marketable job skills that can enhance their future employability, and (c) be able to clarify their career goals (Schambach & Dirks, 2002).

Fleming and Eames (2005) found that students believed that, while in the workplace, they learned multiple skills including communication, time management, reflective thinking, and problem solving along with a greater understanding of the workplace and its environment. Other benefits of cooperative experiences include enhanced thinking, motivation to learn, learning about the work environment, and understanding personal career interests (Smith et al., 2009). Kift, Butler, Field, McNamara, and Brown (2013) stated that students use internships to gather real-world experience before graduation in order to be prepared for the workplace upon graduation. Schambach and Dirks (2002) discovered that students are able to use internships to better understand coursework and bring a new focus toward excelling in their academic work. The research method and student learning outcome for the aforementioned studies related to internships and cooperative experiences are displayed in Table 1.

Table 1

Internships and Cooperative Experiences and Student Learning Outcomes

Paper cited	Method of study	Student learning outcome
Cates & Jones, 1999	Literature review of internships and design of a way for students to evaluate internship experience.	Students experienced workplace culture, new skills, and motivation to learn.
Fleming & Eames, 2005	Questionnaire surveyed 42 students. Examined whether or not amount of time spent in cooperative experience was enough to understand the workplace and learn about what skills can be applied from their classes. Also reviewed what students learned during cooperative experience.	Students practiced communication and interpersonal skills and experienced workplace culture and responsibility of a project.
Kift, Butler, Field, McNamara, and Brown, 2013	Focus groups and online surveys were conducted on senior law students at an Australian university to learn about the impact of various learning techniques on students.	Students gained work experience and valuable interpersonal skills from the internships. They learned that there is value in the skills and knowledge they gain from their coursework.
Schambach & Dirks, 2002	70 students in computer science, information systems, and telecommunications majors were surveyed to reflect on internship experiences.	Students practiced technical skills and interpersonal skills. They obtained valuable real-world experience while observing potential employers.
Smith et al., 2009	Online survey of 32,000 students at Australian universities with some follow-up interviews were conducted about their cooperative experience and what students were getting out of it.	Students practiced technical and personal skills to become more marketable. They also experienced real-world settings and exposure to the industry.

Industry tours/field trips

Kisiel (2006) described field trips as the most common learning experiences that take place out of the classroom. One example of a field trip is going to a facility and touring the facility in person. Field trips often focus on activities that cannot be conducted in the classroom (Kisiel, 2006). Industry tours allow students to view and understand the work environment (Patil et al., 2012). Students observe workers while on the tour, allowing them to see what skills are used and can be applied in the workplace as well as new technologies in the industry (Townsend & Urbanic, 2013). Usually, students returning from their first tour have increased motivation to learn topics covered in class (Patil et al., 2012). Sivan, Wong Leung, Woon, and Kember (2000) found that students were able to make direct contact with business managers to understand real-world situations. Technological advancements now allow for virtual field trips to replace actual field trips as in-class learning experiences. Spicer and Stratford (2001) studied the effect that replacing a real field trip with a virtual field trip has on students. For the virtual field trip, the students were given the software “Tidepools” to be used during class time. Tidepools is a computer program used in the classroom to simulate a biology environment. After going on the real field trip, students expressed that Tidepools was not a viable option over a real field trip. However, they did believe that Tidepools would be useful to prepare future students for a real field trip (Spicer & Stratford, 2001). Some students mentioned that the virtual field trip turned out to be a “good and enjoyable way to learn” but that there was no way that it could replace a real field trip (Spicer & Stratford, 2001). Details of industry tour studies and student outcomes are provided in Table 2.

Table 2

Industry Tours and Student Learning Outcomes

Paper cited	Method of study	Student learning outcome
Patil et al., 2012	Used industry tours, team based projects, and lab experiments to see what students learned from four mechatronic classes over three academic years (2008–2011) at Clemson University (class sizes not stated).	Students observed a manufacturing environment, interactions between humans and machines, workplace culture, important skills, and importance of multidisciplinary studies.
Sivan Wong Leung, Woon, & Kember (2000)	Reviewed videos, quizzes, handouts, assignments, games, presentation, case studies, discussions, and a hotel trip to see which was better for creating interest learning effectively among students from hotel human environment, human resources management, and economics majors.	Students rated the hotel trip to be the most effective when learning, case studies; discussions were also rated highly. Videos, assignments, and quizzes were rated among the least effective. Students learned about preparing for careers, applying knowledge, and developing independent learning skills.
Spicer & Stratford, 2001	Surveyed 59 total students via questionnaire looking at student perceptions of virtual field trip versus actual field trip.	Students do not have the same experience with virtual field trip as they do with an actual field trip.
Townsend & Urbanic, 2013	Used the plan-do-check-act in a class of 17 students to determine if industry tour aligned with students' learning outcomes.	Students experienced workplace culture which led to observing important skills needed, daily duties of the workers, and new technologies.

Guest speakers

Guest speakers are subject matter experts who speak to classes to share their personal or professional experiences and knowledge with students. Metrejean, Pittman, and Zarzeski (2002) studied the reflections of students and faculty members upon having a guest speaker in the classroom. Their findings showed that the guest speaker provided a good opportunity for students to obtain information about the working environment, which is usually not discussed in the classroom, and that students also obtained an understanding of the numerous kinds of jobs available upon graduation. The guest speaker topics included interviewing for jobs and types of job opportunities, and students were exposed to real-life experiences. Directly after a guest speaker event, students completed feedback forms that included questions about the benefits of the speaker's talk and also asked for suggestions for continuous improvement, which would be implemented for the next speaker.

In another study, Riebe, Sibson, Roepen, and Meakins (2013) stated that students learn about teamwork in the workplace, problem-solving skills, communication skills, and self-management from guest speakers. Students may also learn about the guest speakers' experiences within the workplace and the transition from college to jobs after college (Rodrigues, 2004). Furthermore, Goldberg, Vikram, Corliss, and Kaiser (2014) studied students' experiences with guest speakers during a capstone project and found that the guest speaker discussed topics that were applicable to the student's projects. Students also indicated that guest speakers did a good job of discussing post-college career paths and opportunities of which the students could take advantage (Goldberg et al., 2014). The research method and student learning outcome for the aforementioned studies related to guest speakers are displayed in Table 3.

Table 3
Guest Speakers and Student Learning Outcomes

Paper cited	Method of Study	Student learning outcome
Metrejean, Pittman, & Zarzeski, 2002	158 accounting students attending speaker events were surveyed; students completed a feedback form for feedback after listening to guest speakers.	Students listened to speakers share their experiences with job interviewing, job duties, and Certified Public Accountant exam.
Riebe, Sibson, Roepen, & Meakins, 2013	150 business students are surveyed for their perceptions of the impact of guest speakers on their knowledge of employability skills development	Students learn about teamwork, communication, problem solving, initiative and enterprise, self-management, and social responsibility and accountability.
Rodrigues, 2004	Questionnaire completed by 631 students and 58 faculty members. Looked into different teaching techniques used in colleges; respondents rated each technique on a Likert-type range.	Students listen to speakers share experiences of workplace environment.
Goldberg, Vikram, Corliss, & Kaiser, 2014	180 students in two sections. Used guest speakers to share experiences with students.	Students hear speakers share their experiences of workplace, applications, patents, and teamwork.

Project-based learning

Project-based learning can be defined as learning that comes from group projects (Thomas, 2000). Thomas (2000) provided the following five criteria for designing these kinds of activities. First, projects should be centered on what students are learning in the course and should be part of the curriculum. Second, these projects should drive students to encounter concepts central to the course. Third, project-based learning activities should have some form of constructive investigation attached to them. Fourth, the projects should be student driven to give the students responsibility for the project. Last, projects must have a real-world aspect to them. Mills and Treagust (2003) stated that project-based teaching helps engineering students apply what they are learning. Jollands, Jolly, and Molyneaux (2012) stated that students are able to gain time management and project management skills during a project, skills that increase their marketability after college when they are trying to find a job. Boaler (1997) discovered that students who were taught using project-based learning were able to understand the importance of topics for future experiences. Grossman (2002) concluded that projects provide students with an opportunity to gather, clean, model, and communicate data from a technical analysis. Details of project-based learning studies and student outcomes are provided in Table 4.

Table 4

Project-based Learning and Student Learning Outcomes

Paper cited	Method of study	Student learning outcome
Boaler, 1997	Researched differences in student performance between a traditional school and a project-based school	Students were able to practice the skills and knowledge during the project.
Grossman, 2002	Reviewed the impact faculty members had on 500 business students during their projects.	Students stated that faculty members were not preparing them well enough during projects.
Jollands, Jolly, & Molyneaux., 2012	Interviewed recent graduates from civil, chemical, and environmental engineering about the effect projects had on them.	Students found the projects beneficial for using skills not taught during lecture as well as overall project management skills.
Mills & Treagust, 2003	Looked at Central Queensland University engineering program and the benefits of projects to the students.	Students developed skills in teamwork, communication, computing, and problem solving.

Problem-based learning

Problem-based learning uses problems to increase knowledge and understanding of course content (Wood, 2003). There are different types of problem-based learning that can be incorporated in the classroom. One type of problem-based learning is the use of case studies, which can be defined as real or simulated studies used to help students understand topics better. As part of such an activity, small groups of students work together to understand the problem and collaborate to come up with a solution for the problem (Loyens, Magda, & Rikers, 2008). Herreid (1994) stated that students who participate in case studies learn by doing. Students develop analytical and decision-making skills and better understand how to deal with real-world problems (Herreid, 1994). Hung, Jonassen, and Liu (2008) found that students have better long-term retention of knowledge, better problem-solving skills, and increased confidence after using case studies in class. Hmelo-Silver (2004) suggested that students develop problem-solving skills, increase their ability to collaborate on work, and become more motivated to learn through the use of case studies. Savery (2006) suggested that students who collaborate during problem-based learning are able to build communication, work ethic, and analytical skills. The following section provides a discussion of the results from the literature review and the advantages of industry engagement for industry, academic institutes, and students.

Discussion

The reviewed literature provides a strong case that industry engagement is an important part of student learning due to the experience and knowledge gained through each engagement activity. The majority of previous studies, with some exceptions such as those by Rodrigues (2004) and Spicer and Stratford (2001), focused on reviewing an individual activity as opposed to multiple activities. Other studies have reviewed one particular activity within the realm of student industry engagement, with the focus being on what students obtained from the engagement activity, how students learned from the activity, and if the activity was effective at increasing student learning.

Student industry engagement is advantageous not only for students but also for the educational institutions and the industries who participate in the engagement activities (d'Este & Perkmann, 2011). Educational institutions are able to receive feedback about their academic programs and any changes that could be made to improve the programs. Student intern and industry feedback informs the institution of skills or knowledge that can be incorporated into future program curricula and courses (Schambach & Dirks, 2002). Educational institutions can also gain research opportunities with a company by, for example, helping to improve existing products or solving a problem that the company has. Perkmann (2007) described how university–industry partnerships can vary in size from a small temporary project to a large project that involves hundreds of people. He also discussed how students can be involved with university–industry partnerships through working for faculty members who are in contact with the industry. Research partnerships allow students and educational institutions to promote new patents, papers, and academic consulting (Perkmann, 2007).

Student industry engagement also provides industries with opportunities for future recruitment of interns and full-time workers as well as possible opportunities to have an impact on curriculum design (Schambach & Dirks, 2002). D'Este and Perkmann (2011) researched how industries interact with educational institutions to promote university–industry centers where research can be conducted. Academic–industry partnerships can take the form of collaborative research, consulting, and contract research (Perkmann et al., 2013). Industries also can collaborate with universities to gain support for the training and recruitment of students (d'Este & Perkmann, 2011).

Students benefit from industry engagement both while still at the university and in the future. Industry engagement activities allow students to gain real-world experience, whether the activity is in or out of the classroom setting. Guest speakers, case studies, and virtual plant tours allow students to gain an understanding of the workplace while still in the classroom. Guest speakers provide students with information about topics that can include what students can expect in their future workplace, how to get internships, and what different opportunities there are in the industry. Case studies require students to apply their classroom learning to solve a real-world problem. Out-of-class experiences can range from internships to plant tours. Students gain valuable job experience with companies while they are participating in an internship or cooperative experiences (Schambach & Dirks, 2002). It is possible for some internships or cooperative experiences to turn into full-time job offers upon completion of the students' education (Smith et al., 2009). After graduation, students can act as a liaison between companies and their alma mater (Perkmann, 2007). How the educational institutions, industry, and students interact is shown in Figure 1.

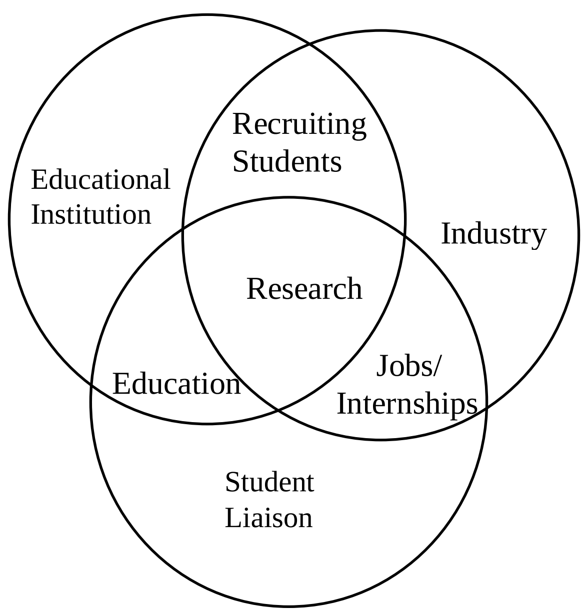

Figure 1. Relationship among industry, educational institutions, and students

Developing industry relationships requires a significant investment of time and resources by students, faculty members, and industry partners. Effective industry engagement, partnered with regular classroom learning, provides students with the most advantageous learning experience possible (Herrmann, 2013), and it is important to optimize industry engagement activities to provide students with the most advantageous learning experience possible. Some industry engagement activities may be more effective than others because of how a particular activity is delivered to the students and what kind of information or skills the students utilize during different activities. Currently, there is no systematic way to evaluate if the industry engagement activities being used are the most effective for student learning. The possibility that the most effective industry engagement activities are not being used leads to the need for continuous improvement tools to be utilized when setting up industry engagement activities.

Limitations

This study was based on literature covering industry tours, field trips, guest speakers, internships and cooperative experiences, project-based learning, and problem-based learning. One limitation is that this research was based on books or papers that were published, as opposed to other work that may have been completed but not published, which may have produced a slight bias toward published work. Another limitation is that not all the papers reviewed were about undergraduate students in the engineering and technology fields. This could be a limitation because students with different majors could respond to industry engagement activities differently. However, reviewing studies that included students not in the engineering and technology field increased the amount of information that could be used to illuminate this study's topic.

Conclusion and Future Work

Based on the review of the literature concerning the benefits of industry tours, field trips, guest speakers, internships or cooperative experiences, and project-based learning, two main areas where future work should be focused have been identified. First, industry engagement activities should be researched using a holistic approach, which would allow activities to be viewed with regard to student learning as a whole instead of reviewing one individual activity at a time. Researching industry engagement activities with a holistic approach would provide analytical findings that could be used to better determine which of the activities is more effective at increasing student learning. This is important as faculty members look for ways to enhance student learning by providing them with the most effective learning techniques. The researchers suggest implementing a survey or structured interviews to obtain student perceptions of industry engagement activities in a holistic way. The authors also suggest analyzing the data from survey or interview responses in a statistical analysis model such as an analysis of variance or structural equation modeling. Once the more effective engagement activities are identified, the results can be provided to faculty members to assist them when they are setting up their next industry engagement activity.

Second, continuous improvement should be incorporated when looking at the effectiveness of industry engagement. Industries have been using continuous improvement tools for many years to make their process efficient and to save money (Bessant & Caffyn, 1997; Callahan, Jones, & Smith, 2008). Lean manufacturing, six sigma, and lean six sigma are continuous improvement concepts used by companies to reduce processes and waste in systems (Bhuiyan & Baghel, 2005; Jones, Smith, & Callahan, 2010; Todorova & Dugger, 2015). Using continuous improvement tools will allow the more effective industry engagement activities to be used alongside classroom teaching.

The implementation of plan-do-check-act (PDCA), which is already well known in industry for continuous improvement, is suggested here. Toyota's business practices is an example of where PDCA has been incorporated into a company's processes for continuous improvement; Toyota uses PDCA to address problems in a systematic way (Schwagerman & Ulmer, 2013). In addition, Borys, Milosz, and Plechawska-Wojcik (2012) used the PDCA process to strengthen cooperation between industry and the university. Borys et al. (2012) used a survey to determine what students were getting from their internship and how it fit into their coursework; then, they implemented PDCA to improve the internship experience. The PDCA process should be implemented to facilitate continuous improvement with industry engagement.

Currently, the first two steps of the PDCA process are being implemented for industry engagement. First, a faculty member interacts with a company to set up the industry engagement activity. The planning that goes into setting up an engagement activity takes time and dedication from the faculty member and company personnel. To set up an industry engagement activity, the faculty member first must contact a company in advance to discuss what topics they want the students to observe or to cover and agree on a date for the activity. Then, the students participate in the industry engagement activity, whether it is in the classroom or outside the classroom. An activity outside the classroom, such as an industry tour, requires time for the students and faculty member to travel to the facility, complete the tour, and travel back to the university. To continue with the PDCA process, it is suggested that a survey or a semi-structured interview with students and industry personnel be implemented to assess the effectiveness of current activities being used. With the findings from this research, faculty members may assess if the engagement activities they are using are the most effective for the students. To complete the continuous improvement process, the instructors could then act to either keep the industry engagement activity or look to promote a different type of engagement activity, depending on the results of the evaluation tool. The PDCA process is a useful tool to confirm that an industry engagement activity is effective at increasing student learning.

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CHAPTER 3. SYSTEMATIC ANALYSIS OF JUNIORS' AND SENIORS' LEARNING THROUGH INDUSTRY ENGAGEMENT ACTIVITIES

Manuscript in progress to be sent to undecided journal

Caleb Burns and Shweta Chopra

Abstract. *Industry engagement activities are used alongside regular classroom learning to provide students with more knowledge about the workplace and how classroom learning can be applied to real-world scenarios. Industry engagement students are exposed to include: (a) case studies, internships, (b) industry tours, (c) industry videos, (d) industry focused final projects, (e) professional organization involvement, and (f) guest speakers. Previous research provides evidence that these industry engagement activities add to student learning (Braxton, Milem, & Sullivan, 2000; Burns & Chopra, 2017; Fleming & Eames, 2005; Patil et al., 2012; Perkmann, 2007; Sivan, Wong Leung, Woon, & Kember, 2000; Smith et al., 2009). Yet, there is a dearth of research which analyzes all industry engagement activities with the same subject group to see if industry engagement activities differ in the amount of student learning they promote. Determining the most effective industry engagement activity is vital as the instructor and industry personnel provide their valuable time and resources to set up and complete the activity. This study analyzes the responses of junior and senior students in industrial and agricultural technology on their perception of the effectiveness of industry engagement. T-tests, a Bonferroni adjustment, and effect size testing were used. Using these findings, instructors can look to incorporate industry engagement activities that correlate with higher student learning. Results indicated that juniors and seniors had similar perceptions of learning for all industry engagement activities with the exception of professional organization involvement.*

Keywords. *Student learning, industry engagement, juniors, seniors, technology*

Introduction

Industry engagement provides multiple advantages when used alongside classroom learning: (1) to provide students with knowledge about industry prior to graduation, (2) to provide students with a way to network with companies to help them find internships and jobs, and (3) to provide students with a non-traditional method of learning classroom topics (Burns & Chopra, 2017). Students can use the industry exposure to create a network with industry professionals to help them with finding internships before graduation and potential job offers upon graduation (Fleming & Eames, 2005; Mills & Treagust, 2003; Smith et al., 2009).

Students learn in two ways: actively and passively. Traditional classroom learning has been defined as passive learning, to include: lectures from instructors, presentations, readings from books, or other supplementary readings (Hwang, Lui, & Tong, 2005). Active learning requires students to be engaged with the learning process and requires for students to work together in groups (Braxton et al., 2000; Dewey, 1997; Nilson, 2010). Students who are engaged in the active learning process are able to retain information and knowledge and return with a positive attitude towards their classroom learning (Braxton et al., 2000; Graham, Tripp, Seawright, & Joeckel, 2007; Nilson, 2010).

For this study, industry engagement activities were defined as: (a) case studies, (b) internships, (c) industry tours, (d) industry videos, (e) industry focused final projects, (f) professional organization involvement, and (g) guest speakers. Previous studies reviewed industry engagement activities to demonstrate how they impacted students (Graham et al., 2007; Kift, Butler, Field, McNamara, & Brown, 2013; Patil et al., 2012; Smith et al., 2009) and typically reviewed a single industry engagement activity during the study. These studies found that industry engagement activities create a positive on impact student learning; however, there is little research comparing the activities to determine which is most effective at enhancing student learning. This research provides instructors a measure of effectiveness of industry engagement activities. Therefore, they may re-design their course to include activities where student learning is enhanced.

For this study, an aspect of student learning is defined as the learning outcomes students display during industry engagement activities or after the industry engagement activity. For this study, the six aspects of learning were defined as: (1) skills used or applied, (2) daily job duties, (3) workplace culture, (4) pursuing a career in the field, (5) applicable course work, and (6) learning about a potential employer. Each aspect of learning will be further defined in this paper. The present study measures and compares junior and senior perceptions of effectiveness of industry engagement activities on aspects of their learning.

In the following sections of this paper, the literature review section first presents a discussion on different aspects of learning that students are exposed to and similarities and differences between juniors and seniors. Next, the research methodology section presents the research question, the development of the survey, sampling method, the hypothesis to be tested, and the data analysis. Finally, a discussion about the data, limitations, and future work will be explored in the discussion section.

Literature Review

The purpose of incorporating industry engagement activities are to motivate students, expose students to the workplace setting, and provide students with industry contacts for networking purposes (Kisiel, 2006; Mills & Treagust, 2003; Smith et al., 2009). The combination of the six aspects of learning allow students to gain knowledge of the industry. Therefore, they become motived as students before graduation and may become better professionals upon graduation. Researchers have identified that students returning from industry engagement activities are more motivated to learn after an activity that interests them (Patil et al., 2012). Braxton et al. (2000) discovered that students who can relate their in-class learning to industry return from industry engagement activities with a desire to pursue the field of study. In addition students who are able to relate the classroom learning to their industry engagement experiences are more likely to retain the knowledge and recollect it later (Thomas, 2000).

Exposing students to workplace operations allows students to gain an understanding of daily job duties that they could encounter and workplace cultures existing at different companies. Providing students with various industry views allows students to explore the types of industries they would be more interested to work in (Schambach & Dirks, 2002). Learning about workplace culture gives students a representation of how personnel work together to complete tasks (Fleming & Eames, 2005).

Allowing students the opportunity to learn about potential employers exposes them to contacts for internships or jobs in the future (Guler & Mert, 2012). Industry personnel that have personal contact with students can guide them towards skills or topics that are new in the industry. Industry personnel can also act as a mentor or role model to students (Smith et al., 2009). A role model is an individual who inspires other individuals to make career based decisions and sets an example of how to achieve goals (Bosma, Hessels, Schutjens, Praag, & Verheul, 2012). During these industry engagement activities, students interact with industry personnel which may inspire them to find pursue a career in a similar field of study. Students who actively participate in the learning process and find a positive role model result in achieving more academically and have an increased retention of knowledge (Austad, Avorn, & Kesselheim, 2011; Bosma et al., 2012; Graham et al., 2007).

Motivating students, exposing students to the workplace, and providing students with industry contacts for networking purposes can be divided into the six aspects of learning: (1) workplace culture, (2) skills used or applied, (3) daily job duties, (4) applicable coursework, (5) pursuing a career in the field, and (6) learning about a potential employer. These six aspects of learning are important to review since industry engagement activities should provide students with additional learning opportunities along with traditional classroom learning. A traditional classroom setting would include lectures from an instructor and readings from the text. Students are given an opportunity to learn about topics that are not specifically included in the textbook. However, they are still important for students to learn about before graduating and becoming members of the workforce. Interacting with industry personnel and the industry setting allows students to ask questions directly and gain insight about the industry from a direct source rather than from a second-hand source. These six aspects of learning are discussed in the following sub-sections.

Workplace culture

Incorporating industry engagement activities enables students with a way to learn about workplace culture first hand or to ask specific questions to industry personnel about workplace culture (Haag, Guilbeau, & Goble, 2006). Workplace culture can be defined as the most immediate culture that staff experience through everyday interactions with the work environment (Manley, Sanders, Cardiff, & Webster, 2011). Workplace culture includes, but is not limited to: company policies, company mission and values, work environment, co-workers, how workers behave and make decisions, and communication among workers (McShane & Von Glinow, 2015). Students learn about workplace culture through hearing about personal worker experiences, actually being in the workplace during internships and projects, and viewing the work environment during tours and internships (Fleming & Eames, 2005; Haag, Guilbeau, & Goble, 2006; Schambach & Dirks, 2002; Sivan et al., 2000). In order to assist with the transition from the educational institution to the workplace, it is beneficial for students to gain knowledge regarding workplace culture. Providing students with various interactions with workplace culture allows students to view how different companies work and how a job they are interested in is applied in the workplace.

Skills used/applied

The level of understanding of skills used in the workplace changes from when a student is in college to when they are working in the industry (Park & Cha, 2013). Students learn about skills that the industry uses from the classes they are taking such as: decision making skills, communication skills, analytical skills, teamwork, problem solving, communication, and self-management skills (Herrid, 1994; Schambach & Dirks, 2002; Smith et al., 2009). Students return from industry engagement activities more willing to learn and apply the skills they learn in class to real-world situations. Industry engagement activities provide students with an opportunity to see or hear about the kinds of skills should be mastered in order to prepare for entering the workplace. Students who can understand that topics discussed in the classroom have application in the workplace are able to retain the knowledge of those specific skills and work on honing these skills.

Daily job duties

Job duties are defined as “tasks assigned” to a worker that are expected to be completed (McShane & Von Glinow, 2015). Students learn about daily job duties through guest speaker experiences and observing various tasks during internships and tours, which leads to gaining an understanding of daily job duties during projects when they must complete them (Guler & Mert, 2012; Jollands, Jolly, & Molyneaux, 2012; Patil et al., 2012; Riebe, Sibson, Roepen, & Meakins, 2013). Having an understanding of daily job duties helps students decide which kinds of jobs or careers to pursue. There are various jobs that students with a technology degree may pursue and the ability to see or hear about daily job duties can help students decide the types of jobs they would or would not like to have. Students who have not completed an internship can also learn about daily job duties through guest speakers, industry tours, and during some industry focused projects.

Applicable coursework

Applicable course work includes any programs learned, any technology learned, and any knowledge gained from lecturers or other means of teaching (Sivan et al., 2000). Being able to recall coursework after graduation assists students to become better professionals upon graduation, thus making them more marketable when looking for a job (Smith et al., 2009). Students learn about applicable coursework through guest speakers discussions, during internships when they can apply their classroom learning, and when they can apply their learning through projects (Cates & Jones, 1999; Leicht, Zappe, Hochstedt, & Whelton, 2015; Rodrigues, 2004). Students who have an understanding of how coursework can be applied in the industry helps students appreciate their coursework and know that it is valuable knowledge. Students have to be encouraged that what they are learning in the classroom is applicable to what they will be seeing in industry. Students may also understand how specific topics of interest (i.e., automation, lean, facility planning) are applied in the workplace and may become more interested in finding a job or internship dealing with such topics due to industry engagement. Students may also learn about topics or areas of interest that they may not have known about prior to industry engagement activities that they will be interested to learn about in their next semester or even after graduation.

Pursuing career in the field

Industry engagement activities provide students with an idea of what they are able to do with their degree upon graduation (Metrejean, Pittman, & Zarzeski, 2002). Students understand various job opportunities and personal career interests they can work in upon graduation through listening to guest speakers, seeing what applications there are during tours, and partaking in an internship (Guler & Mert, 2012; Rodrigues, 2004). Internships provide students with a good understanding whether or not they wish to pursue a career in that specific field of study (Patil et al., 2012). Students in the technology field have a variety of jobs that are available. Industry engagement with a field such as the medical industry is not something that a technology student may think about applying to until learning that the medical industry also uses topics such as lean manufacturing in their facilities. These types of industry engagement activities provide students with a different point of view when researching the various industries that they are eligible to apply for and how their knowledge can be applied to those industries (Stefanidis et al., 2005). Learning about pursuing a career in the field is not always a positive experience, if a student takes an internship and find that they did not enjoy the field that they were in that is still a positive outcome.

Learn about potential employer

Industry engagement activities allow students to interact with companies and learn about potential companies the student may be interested in. Allowing students to become engaged with industry personnel provides them with an opportunity to ask specific questions of industry personnel, thereby increasing student knowledge of that company as well as the industry with which the company is associated. Students also learn about potential employers through guest speakers talking about their experience. When students are on internships, they also learn about potential employers whom they are working for and how internships could turn into full-time positions (Goldberg, Vikram, Corliss, & Kaiser, 2014; Haag et al., 2006; Sivan et al., 2000). Students may take advantage of industry engagement activities to use those industry personnel as contacts for future jobs or internships. Students should learn about potential employers early in their collegiate career so they may work on creating a network with industry quickly.

These six aspects of learning help to motivate students, expose students to the workplace, and provide students with industry contacts for networking purposes and help to make students more successful with their professional career. Industry engagement not only benefits students but also benefits the company involved as well as the academic institution involved (Burns & Chopra, 2017). Academic institutions are provided with an opportunity to gain research partnerships with the industries involved (Perkmann et al., 2013). Industries gain the ability to work with academic institutions to provide students with internships which could turn into full-time positions, and can also provide the academic institution with information about current skills, knowledge, and standards in the workplace (Schambach & Dirks, 2002).

This paper will focus on juniors and seniors and their perception of the effectiveness of these activities because these students are involved with core classes pertaining directly with their major. Juniors and seniors are able to apply their knowledge from their classes to the industry engagement activities more so than freshman and sophomores. The next section defines juniors and seniors and review previous scholarly works to see whether they tend to have similar learning outcomes.

Juniors and seniors

For this study, juniors and seniors were reviewed to see if they had similar perceptions of the effectiveness of industry engagement activities. The University defines juniors as having at least 60 credits and seniors as having at least 90 credits. These are the definitions the author chose to utilize for this study.

Previous scholarly work has found little to no statistical difference between juniors and seniors. Rachal, Daigle, and Rachal (2007) reviewed the types of learning difficulties students faced and found that freshman students were the only group of students who had any differences with the learning difficulties. Bradford and Wyatt (2010) reviewed academic standing, ethnicity, and their influence on facilitated learning, engagement, and information fluency and found that juniors and seniors had no significant differences with these topics. Carter III, Michel, and Varela (2012) reviewed online students and in-class students and found that there was no evidence to support that seniors had a superior learning outcome compared to juniors. Stefanidis, Korndorffer, Sierra, Touchard, Dunne, and Scott (2005) examined student skill retention after using both a virtual reality simulator and a video trainer simulator for junior and senior medical students. The results of the study provide evidence that there was no statistical difference between juniors or seniors after using the simulators.

Neuman, Finlay, and Neuman (1989) provide some reasoning as to why juniors and seniors tend to have similar learning versus freshman and sophomores. Juniors and seniors have completed most of the academic “hurdles” that freshman and sophomores have yet to face (Neumann & Finaly-Neumann, 1989). Walker (2011) followed students pre and post internship to examine the impact the internship had on student Grade Point Average (GPA), persistence to graduate after the internship, and if taking an internship effected the time to graduate. Internships had a positive impact on student GPA, retention, and degree completion. However, there were no questions asking what about the internship made students study more to have a better GPA or to decide to stay in their degree until they completed it. Table 1 outlines the article reviewed, what the purpose of the research article was, and what the outcome was for each article.

Table 1

Juniors' and seniors' learning difference

Paper cited	**Purpose of the research?**	**What was the outcome?**
Rachal, Daigle, Rachal, 2007	Surveyed freshman, sophomores, juniors, and seniors about their learning difficulties and learning needs. Liberal arts students.	Freshman were the only significant statistic that were different from sophomores, juniors, and seniors.
Bradford, Wyatt, 2010	Reviewing academic standing, ethnicity and their influence on facilitated learning, engagement, and information fluency for freshman, sophomores, juniors, and seniors. For online students	Freshman and sophomores had significant differences between juniors and seniors.
Carter III, Michel, Varela, 2012	Difference between online students, and in class students, hypothesize that seniors will have superior learning outcomes to juniors. Business students.	No evidence to support seniors had superior learning to juniors.
Stefanidis, Korndorffer, Sierra, Touchard, Dunne, Scott, 2005	Assessing skill retention from virtual reality and a video trainer, medical students either juniors or seniors	No statistical difference between juniors and seniors skill retention.
Neumann, Finlay-Neumann,1989	Reviewed why juniors and seniors had a lower dropout rate then freshman and sophomores	Juniors and seniors both have passed the major academic "hurdles" and thus have a different mindset then freshman and sophomores.

Walker, 2011	Long term study to see if internships improved student GPA, persistence to complete to graduation, and impacted time to graduate. Business students.	GPA was improved by 3.29% on a 4.0 grading scale, 5 of the 18 students did not continue to graduation, and having an internship did not impact the time to graduate.

This study focuses on juniors and seniors since 75% of the students who graduate with a technology degree are transfer students who enter the program sometime after their freshman year. This means that only 25% of students pursue the technology degree from their freshman year. Juniors and seniors have the experience with core classes and there are more students because of the amount of students who transfer into the degree. The literature reviewed examines difficulty of student learning or is based on student grades. This research however, focuses on how effective the aspects of learning were for students.

Research Methodology

Research question

Are juniors and seniors impacted differently for each of the six aspects of learning* for each industry engagement activity**?

*(1) skills used or applied, (2) daily job duties, (3) workplace culture, (4) pursuing a career in the field, (5) applicable course work, and (6) learning about a potential employer

** (a) case studies, (b) internships, (c) industry tours, (d) industry videos, (e) industry focused final projects, (f) professional organization involvement, and (g) guest speakers

Instrument development

The student learning outcome based on individual industry engagement activity was evaluated through a 62 questionnaire-based survey. Construct measurements were obtained from previously validated questionnaire items (Haag et al., 2006; Metrejean et al., 2002;

Rodrigues, 2004; Watson & Lyons, 2011). Activities were chosen based on the student curriculum in a junior and senior level technology program. After analyzing the curriculum, the most common form of identified industry engagement activities are as follows: (a) case studies, (b) internships, (c) industry tours, (d) industry videos, (e) industry focused final projects, (g) professional organization involvement, and (g) guest speakers. Six aspects of student learning were considered for questionnaire development based on (a) skill sets which instructors believe students need to learn after completion of each activity and course, (b) past literature which is focused on measuring student learning outcomes (Burns & Chopra, 2017; Goldberg et al., 2014; Herrmann, 2013; Riebe et al., 2013; Rodrigues, 2004), and (c) based on the authors' prior experience.

A seven-point Likert-type set of scores ranging from strongly disagree (1) to strongly agree (7) was used to measure participants' perceptions regarding industry engagement and its effectiveness on student learning. The moderating variables measured were age, gender, education level, and grade point average.

Face validity is subjective and measures the straightforwardness of questionnaire items based on the description provided in the survey. It is important to ensure that participants can understand the questionnaire easily and draw consistent inference before selecting their response. For maintaining the integrity of the questionnaire it is necessary to have clear language, word usage and readable sentences (DeVon et al., 2007)To achieve face validity for refining survey questionnaire feedback of the experts (faculty) and few potential participants (students) are important to consider. Face validity was assessed through 20 hours of meetings with two undergraduate students with similar characteristics to those in the target sample group but not in the final sample. Three graduate students and one faculty member served as an expert for refining the survey.

Survey dissemination

The survey was disseminated using Qualtrics®, an online survey dissemination and analysis software. An online survey was chosen because it provided access to all participants and was efficient in terms of both time and cost (Wright, 2005). All research participants had access to high-speed internet and computers to participate in the study. The survey was sent to students via university e-mail. Student e-mail address was obtained by the instructors whose classes were being used to collect data from. Data collection took place in compliance of the internal review board procedures and protocols. Student's anonymity was maintained throughout the research. Once students read the consent form and agreed to participate, a questionnaire based survey opened. Students could exit the survey at any time.

Sampling

We adopted a judgement technique, whereby the researchers use their judgement when selecting a group that would be representative of the entire population (Kothari, 2004). Using this technique, the researchers selected a class in which students had already participated in various industry engagement activities. Students' industry engagement experience was confirmed by reviewing the class syllabus. The students surveyed were juniors and seniors pursuing a degree in industrial technology, agricultural systems technology, or a dual major in both industrial and agricultural systems technology. The students were enrolled in junior- or senior-level technology course. Students in this class participated in industry activities such as guest speakers, case studies, and industry videos to learn topics discussed in class. Internships are required as part of the degree program in industrial technology or agricultural systems technology.

The criterion for selecting students was whether they had participated in industry engagement activities during class. For this study, a junior-level technology class was used knowing that the students had participated in various industry engagement activities. Students were provided with a brief introduction to the research and the impact their participation would have. The introduction provided an overview of the research study, a brief overview of the information which will be collected and the purpose of data collection.

The survey was sent to 105 students. From these, 94 complete responses were returned, for a response rate of 89.5%. Descriptive statistics of the 94 responses are presented in Table 2 below.

Table 2: Characteristics of the Respondents

Characteristics	Number	Percent (%)
Gender		
Female	6	6
Male	88	94
Age		
19-20	11	12
21-22	61	65
23-24	16	17
25+ older	6	6
Grade level		
Juniors	43	46
Seniors	51	54
Internship		
Juniors	37	86
Seniors	48	94

Hypothesis

H_{01}: The mean scores for student perceptions of activities are similar for juniors and seniors for each aspect of learning

H_{A1}: The mean scores for student perceptions of activities are different for juniors and seniors for each aspect of learning

This hypothesis was evaluated using multiple *t*-tests to compare student perceptions across the activities. A *t*-test allows for a comparison between two groups (Armstrong, 2014). The null hypothesis states that the mean scores for the aspects of learning are similar to each other and that there is no difference between juniors and seniors. The alternative hypothesis states that at least one of the mean scores for an aspect of learning is not equal to the mean score for another aspect of learning, providing statistical evidence that there is a difference in student perceptions between juniors and seniors.

A Bonferroni adjustment for the alpha level is used to reduce the chance of obtaining false positive results when multiple *t*-tests are performed on a single set of data (Armstrong, 2014). The Bonferroni adjustment uses the desired alpha level divided by the number of tests being completed, which produces the new alpha level and *p*-value to be used for the analysis. Tests for the hypothesis were conducted using Bonferroni-adjusted alpha levels of 0.0012 per test (0.05/42). The Bonferroni-adjusted value was used for the new *p*-value to be tested against.

Data analysis

Data analysis was completed using the software JMP®, a statistical analysis software. Students were grouped by juniors and seniors as per what they self-reported to be on the survey. The data were uploaded into JMP® which found the mean score for both groups.

JMP® then used the mean scores of juniors and seniors in a *t*-test, which then provided the *p*-value for each aspect of learning. This *p*-value was then used with the Bonferroni-adjusted value to determine which of the aspects of learning had a 95% protected level of statistical significance. Results with statistical significance mean that juniors and seniors do not have similar perceptions of learning from that industry engagement activity. Table 3 provides the results of the data and breaks the data into each industry engagement activity, the aspect of learning being reviewed, junior mean score, senior mean score, the *p*-value of the comparison, and finally the conclusion of each row.

Table 3: Comparison of juniors and seniors for engagement activities

1	2	3	4	5	6
Activity	Aspect of Learning	Junior	Senior	*P-value*	Conclusion
Case Study	Skills used or applied	5.21	5.35	0.243	Fail to reject null hypothesis
	Daily job duties	5.44	5.43	0.482	
	Pursuing a career in the field	4.79	4.86	0.396	
	Applicable course work	5.21	5.33	0.282	
Guest Speaker	Skills used or applied	5.60	5.55	0.401	Fail to reject null hypothesis
	Daily job duties	5.56	5.41	0.246	
	Workplace culture	5.42	5.18	0.149	
	Pursuing a career in the field	5.02	5.00	0.137	
	Applicable course work	5.56	5.43	0.276	
	Learning about potential employer	5.74	5.22	0.008	
Internship	Skills used or applied	5.86	5.90	0.421	Fail to reject null hypothesis
	Daily job duties	5.86	5.53	0.085	
	Workplace culture	5.89	5.67	0.167	
	Pursuing a career in the field	5.40	5.49	0.359	
	Applicable course work	5.47	5.49	0.460	
	Learning about potential employer	5.63	5.59	0.433	
Professional Organization Involvement	Skills used or applied	5.60	4.80	0.0008	P-value is lower than α of .0012, reject null hypothesis.
	Workplace culture	5.49	4.53	0.0001	
	Pursuing a career in the field	5.58	4.75	0.002	Fail to reject null hypothesis
	Applicable course work	5.56	4.65	0.0002	P-value is lower than α of .0012, reject null hypothesis.
	Learning about potential employer	5.89	4.73	0.00001	
Projects	Skills used or applied	5.64	5.47	0.469	Fail to reject null hypothesis
	Daily job duties	5.55	5.37	0.187	
	Pursuing a career in the field	5.26	5.02	0.439	
	Applicable course work	5.50	5.31	0.448	
	Learning about potential employer	5.14	4.90	0.432	
Tours	Skills used or applied	5.51	5.45	0.410	Fail to reject null hypothesis
	Daily job duties	5.47	5.43	0.450	
	Workplace culture	5.56	5.45	0.340	
	Pursuing a career in the field	5.44	5.20	0.186	
	Applicable course work	5.23	5.33	0.360	
	Learning about potential employer	5.44	5.45	0.486	
Videos	Skills used or applied	4.91	4.94	0.354	Fail to reject null hypothesis
	Daily job duties	4.98	4.88	0.171	
	Workplace culture	4.67	4.67	0.317	
	Pursuing a career in the field	4.93	4.57	0.023	
	Applicable course work	4.74	4.45	0.090	
	Learning about potential employer	4.98	4.88	0.171	

N=94, scale: 1 (strongly disagree) to 4 (neither agree or disagree) 7 (strongly agree) * Bonferroni Corrected Value α=0.0012

Column 1 in Table 3 lists the industry engagement activity that is being reviewed. Column 2 lists the aspect of learning that pertains to the industry engagement activity being reviewed. Column 3 provides the mean score for juniors for each aspect of learning. Column 4 provides the mean score for seniors for each aspect of learning. Column 5 indicates the calculated *p*-value for each aspect of learning when comparing juniors and seniors. Column 6 provides the conclusion using the calculated p-value compared to the Bonferroni adjusted value. For example, under case study when looking at skills used or applied: juniors mean score was 5.21, seniors mean score was 5.35. The calculated *p*-value for comparing means between juniors and seniors is 0.243, which is greater than the Bonferroni corrected value of 0.0012. The conclusion is to fail to reject the null hypothesis and to conclude that juniors and seniors perceive that they have similar learning when looking at skills used or applied during case studies.

In order to gain an understanding of the magnitude of the difference between the juniors' and seniors' perception of effectiveness of industry engagement activities, the difference was assessed using the effect size values shown in Table 4. Effect size quantifies the size of the difference of the mean scores by comparing the mean differences against their combined standard deviation (Nakagawa & Cuthill, 2007). The value of Cohen's *d* represents how many standard deviations the two groups are apart from each other. Cohen's *d* effect size value d=0.200 suggests a small effect size, effect size value d=0.500 suggests medium effect size, and effect size value d=0.800 suggests high effect size(Cohen, 1977). If two groups don't differ by 0.200 standard deviations or more then there is no meaningful difference, even if the result from the *t*-test is significant. For this research, the effect size provides more use to define the differences of the activities for juniors and seniors. A negative *d* value occurs when the mean score for seniors is larger than the mean score for juniors. An example for reading Table 4: when looking at learning about a potential employer during guest speakers, there was a 0.503 effect which suggests a medium learning significance for juniors.

Cohen's *d* calculations:

$$d = \frac{(M_1 - M_2)}{SD_{pooled}} \qquad SD_{pooled} = \sqrt{\frac{SD_1^2 + SD_2^2}{2}}$$

M_1=Junior mean score

M_2=Senior mean score

SD_1=Junior standard deviation

SD_2=Senior standard deviation

Table 4: Effect Size of activity on learning

Aspect of Student Learning	Effect Size Between Juniors and Seniors (Cohen's *d*)					
	Skills used or applied	Daily job duties	Workplace culture	Pursuing a career in the field	Applicable course work	Learning about a potential employer
Case Study	-0.140	-0.120	N/A	-0.130	-0.240	N/A
Guest Speaker	0.052	0.143	0.217	0.230	0.124	0.503
Internship	-0.042	0.286	0.202	-0.075	-0.021	0.035
Professional Organization	0.679	N/A	0.792	0.629	0.763	0.998
Project	0.164	-0.028	N/A	0.032	-0.028	0.036
Tours	0.047	0.026	0.086	0.186	-0.075	-0.007
Videos	0.079	0.199	0.100	0.419	0.282	0.199

Since professional organization involvement was the only industry engagement activity that produced statistically significant results between juniors and seniors, the authors will focus on the effect size of those aspects of learning. When looking at skills used or applied, workplace culture, applicable course work, and learning about a potential employer the effect size is between (d=0.629 and d=0.998) which means that there is a medium to high difference in learning preferences for these aspects of learning for juniors over seniors. Juniors stated that being involved with professional organizations gave them a way to network with companies, the organizations explained how students can approach finding a career they want to pursue, and allows students to have a closer more personal conversation with industry representatives. Seniors suggest involvement with professional organizations is a way to make connections with peers and used the organization involvements as a reference to make sure they chose a career path that was correct for themselves.

Discussion

Industry engagement requires time and effort for instructors to set up, so, it is imperative that instructors spend their time to provide students with the best learning experience possible. The involved industry representatives also spend time and effort to send a worker to talk to students as a guest speaker, allowing students to walk through the facility for a tour, hiring a student for an internship, or even meeting with a group of students as a professional organization. Therefore, it is important that the industry engagement activity being organized be worth the time and resources for both the academic institution and the industry. Reviewing industry engagement using a holistic approach is important to provide a measure for student perception of effectiveness of each activity so that instructors may structure their classes to incorporate the most effective activities. By reviewing these seven different industry engagement activities with the same group of students, this study produced a measure of which activities are more effective at enhancing student learning for specific aspects of learning, thus, providing instructors with a comparison for their classes. Providing students with activities that improve their learning the most prepares students to become better professionals upon graduation.

The data provide evidence that juniors and seniors have similar perceptions of effectiveness of industry engagement on their learning, with the exception of professional organization involvement. The results align with the literature reviewed in Table 1, which shows that juniors and seniors tend to not have statistically significant differences in learning. This study found that the majority of industry engagement activities found no statistically significant differences between juniors' and seniors' mean scores. With these results, the authors suggest incorporating professional organization involvement for juniors due to that fact that juniors having a statistically significant advantage over seniors when learning about skills used or applied, workplace culture, applicable course work, and learning about a potential employer.

When reviewing the mean scores for each aspect of learning for the activities, it is important to note that there is a practical difference which should be examined. For example, when reviewing skills used or applied for juniors, guest speakers were rated 5.60 and tours were rated 5.51. Both scores are about the middle value of four so there is positive learning for the activities. However, there is very little difference between 5.51 and 5.60, therefore, the instructor in charge would make the decision as to which activity is more practical to complete. Tours require time, money, and a nearby industry that will host the students. In this instance, it could be more practical to have a guest speaker come to the classroom rather than make a trip to the industry. Videos were rated lower than other activities, therefore, it would be beneficial if instructors attempted to apply other means of industry engagement activities before applying videos.

It is important to understand why juniors found professional organization involvement to have more impact on their learning than did seniors. Juniors and seniors have a different mindset for learning depending on how close they are to graduating and beginning their professional career. Of the 43 juniors who responded to the survey, 11 students made comments about clubs that they were involved with on campus but not necessarily professional organizations such as the American Society of Engineering Education and the American Society for Quality. This shows that even clubs on campus that deal with the students' major, i.e., the industrial technology club or the agricultural systems technology club, provide students with an opportunity to enhance their knowledge about industry. Only two juniors made a comment about organizations that they were involved in, not including campus clubs. Juniors found professional organization involvement important to create professional relationships to industry personnel to help them decide their future career paths. This is important for juniors to have because they still have a year left before they have to worry about finding jobs and can still use their relationships with industry to gain internships.

Seniors, on the other hand, are planning or have planned their future professional career already and are less interested in being involved with professional organizations that do not pertain to their plans. The survey did not ask if the students had their career after college planned yet, so no definitive conclusion may be drawn about seniors' plans for their careers. Fewer seniors made a comment about being involved with a club on campus as well. Only 5 of the 51 seniors made a comment about clubs that they were involved with on campus. Only two seniors made a comment about organizations that they were involved in, not including campus clubs. The findings for juniors and seniors align with the literature reviewed in Table 1 when looking at differences between juniors' and seniors' learning. Table 5 provides thematic student comments about each activity and is organized by juniors and seniors.

Table 5 was created using NVivo, which is a word frequency software. Student comments were uploaded into NVivo and common themes were compiled into Table 5 for each industry engagement activity. When looking at junior and senior comments for each industry engagement activity, both students made similar comments about what they learned from each activity. Case studies provided real-world examples for students to relate their classroom learning. Guest speakers discuss job opportunities and how classroom learning applies to the industry. Internships provide students with a first-hand look of how the classroom learning applies to industry. Projects reinforced classroom learning when applied to real-world problems through project management techniques and teamwork. Tours provided students with networking opportunities and were useful to show students how course work is applied in an industry setting. Videos provided a visual for topics students were learning in the classroom.

Table 5: Student comments about industry engagement activities

Activity	Juniors Comments	Seniors Comments
Case Study	Provided real-world experiences that allowed me to apply classroom material to make sophisticated choices during the case study.	Allowed me to apply classroom learning to real-world experiences and gain an understanding of difficulties of the decision-making process.
Guest Speaker	Provide personal experience of potential companies/jobs, able to explain how much classroom learning applies to the industry directly.	Able to talk about how college classes directly apply to industry, elaborate on how industry operates, and discuss the job application process and resumes.
Internship	Gained hands-on learning in real-	Helpful for clarifying areas of interest,

	world setting, makes classroom learning more interesting, provide brief preview of what working in industry is like.	first-hand look at workplace and how classroom learning applies to real-world.
Professional Organization Involvement	Create professional relationships to industry personnel to help them decide their future career paths, found university clubs to be very effective for industry engagement.	Clubs were a way to be involved with the community and with industry personnel, provided networking opportunities and connections with faculty and industry representatives.
Project	Help reinforce importance of classroom learning and simulates an industry project with deadlines and objectives.	Helpful to practice stress of real-world projects, able to apply classroom learning, experience with teamwork, initiative in seeking solutions, and helps to see what topics I am interested in.
Tour	Provided networking opportunities, how content and classroom concepts are applied on large scale, and provided insight on how company works.	Helped to confirm career interests, helped provide me with an internship through networking, helpful to show how course work is applied to the industry setting, and beneficial for the "hands on learns" to learn the material.
Video	Showed company culture, helpful as a visual to understand topics, and were great supplemental material.	Provided a visual for processes we were learning about in class and allowed me to learn about that specific company.

This study was focused on juniors and seniors in a single class in the technology program. The sample size of 94 may have a role in limiting the significance of the results. A post hoc power analysis reveals that with the 94 students used in the study and a standard deviation of 1.12, the power of the test is 0.75. The recommended power value for analysis is typically 0.80 or greater. Therefore, it is possible that not all of the results may be interpreted for the entire technology population. One limitation is that juniors and seniors will have a different mindset when looking at industry engagement. This is because seniors are looking to graduate and start working in industry and juniors are still looking around and wanting to learn more before they make their decision of what kind of work they want to do. Another limitation is that since students are self-reporting what they consider themselves (juniors or seniors) then it depends on the student if they have enough credits to be a senior do they consider themselves a senior or do they consider themselves a junior because they are not far enough into the program to take senior level classes. Students are self-reporting their perception of effectiveness of industry engagement using a seven-point Likert range of response options. Using a seven-point Likert range provides students with three positive, three negative, and a neutral answer. Students who feel their response should be in-between two of the results may opt to either increase their perception or decrease it.

Based on this research, the authors have identified a few areas where future work should be focused. A longitudinal study of a group of students that follows them after graduation to see how their specific industry engagement activities impacted their choices upon graduation is a future research possibility. This longitudinal study could provide insight as to how specific industry engagement activities are impacting students after they graduate. Foreman (2012) examined university clubs and their impact on students. The result was that students who were involved with clubs are found to have a greater impact on leadership development. Another aspect of future work is to incorporate topics such as leadership, teamwork, communication, etc. to see how these topics or skills are included in the industry activities and how they impact students. The authors suggest comparing multiple institutions and their technology students to see if there is a difference with how different institutions are incorporating industry engagement activities.

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CHAPTER 4. SUMMARY AND CONCLUSION

Summary

In summary, this thesis had two main objectives: (1) determining what students learn during industry engagement activities and (2) providing a measure for how effective each activity was for students to learn about the six aspects of learning.

Chapter 2 reviewed previous scholarly work to determine what students gained from the industry engagement activities. This chapter also provided the plan-do-check-act suggestion when incorporating industry engagement activities in the classroom.

Chapter 3 provided an approach for measuring multiple industry engagements to see which activity enhanced student learning among juniors and seniors in the technology program.

Conclusion

In conclusion, students found all industry engagement activities to have a positive impact on their learning. However, juniors found professional organization involvement to have more impact on their learning than did seniors. The comments made by juniors provided evidence that they found the professional organizations to be a way to network and evaluate what jobs are available to them. Seniors found professional organization involvement to be less effective on their learning about skills used or applied, workplace culture, applicable course work, and learning about a potential employer. Seniors have a different mindset than juniors, since the majority of seniors will be focusing on graduating and most likely already have their professional career planned. This is where the seniors and juniors differ, since juniors are typically still planning their professional careers upon graduation.

There were many activities which were rated closely and depending on how much time and resources the activity takes to complete the instructor should decide which activity to pursue. When reviewing the practical difference between activities, videos have a mean score that is lower than the majority of other activities. This means that even though videos have a positive impact on student learning, there are other activities which enhance student learning more. When reviewing activities other than videos, if there is little difference between activities then the instructor should choose which activity to incorporate, then use the plan-do-check-act to ensure that the activity being used is beneficial to students or if the instructor should think about changing to a different activity for future classes.

Limitations

One limitation of this research was that only data at one university was able to be obtained for analysis, therefore the data set may not be representative of the population of all technology students. This research may provide instructors with an idea for what activities they should incorporate. There was little research published on professional organizations and the impact on students. This research provides information as to what students learn while being involved with professional organizations.

Future Work

Based on this research, there are a few areas that have been identified where future work should be focused. First, a longitudinal study which follows students from freshman year through their graduation and beyond college to see how the industry engagement activities impact them beyond the college setting. Collecting data from multiple universities would provide a larger sample to see how students at different institutions rate the industry engagement activities. This would provide a way to compare different institutions to see if there is a difference with how activities are being incorporated. Collecting data from the industry prospective to see if what industry personnel believe are helping students are the same as what actually helps students.

APPENDIX A SURVEY ITEMS

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I learned about daily job duties.							
I learned about a potential employer.							
I learned about skills used in the workplace.							
I learned about coursework that is applicable in the workplace.							
The activity confirmed my interest to pursue a career in this field.							

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APPENDIX B IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 6/1/2015

To: Dr. Shweta Chopra
4344 Elings Hall

From: Office for Responsible Research

Title: Designing curriculum involving industry participation: Assessing student's learning through effective college-industry partnership

IRB ID: 15-328

Study Review Date: 5/29/2015

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**